AMENDMENTS TO THE CLAIMS

Please amend the claims as follows:

1. (Currently Amended) A method for estimating a sequence of transmitted quadrature amplitude modulation (QAM)-modulated signals and space-time block coded signals using an optimal expectation-maximization (EM)-based iterative estimation algorithm in a multiple-input and multiple-output (MIMO)-orthogonal frequency division multiplexing (OFDM) mobile communication system, comprising the steps of:

(a) producing an initial sequence estimation value according to a predetermined initial value using a pilot sub-carrier contained in each OFDM signal received by a receiving side;

(b) producing a normalized value of ~~a~~ the received signal on a channel-by-channel basis using orthogonality between the OFDM signals received by the receiving side, the normalized value of the received signal being produced by a predetermined equation;

(c) producing at least one subsequent sequence estimation value using the initial sequence estimation value and the normalized value of the received signal on the channel-by-channel basis; and

(d) if the at least one subsequent sequence estimation value converges to a constant value, designating the converged subsequent sequence estimation value to be a final sequence estimation value,

wherein the predetermined equation is given by:

$$z_{n,m} = H_{n,m} + w_{n,m} = Fh_{n,m} + w_{n,m}$$

where "$w_{n,m}$" denotes a white Gaussian noise of a channel from an nth transmitting antenna to an mth receiving antenna, "F" denotes a discrete Fourier transform matrix, and "$h_{n,m}$" denotes an impulse response associated with the channel from the nth transmitting antenna to the mth receiving antenna.

2. (Original) The method as set forth in claim 1, wherein the at least one subsequent sequence estimation value produced in step (c) is produced on according to a likelihood function produced by:

$$L(s|\hat{s}^i) = \sum_{m=1}^{M}\sum_{p=1}^{P}\left\{\mathrm{Re}\left[(y_m^p)^H C_p \Lambda_m^i f_p\right] - \frac{\beta_p}{2}\sum_{n=1}^{N}\sum_{a=1}^{J}\sum_{b=1}^{J}\left[x_{n,m}^i\right]_{a,b}\left[f_p\right]_a\left[f_p\right]_b^*\right\}$$

where "Λ_m^i" denotes a matrix of a conditional expected value associated with a channel impulse response and is given by $\Lambda_m^i = \left[\mu_{1,m}^i, \mu_{2,m}^i, \cdots, \mu_{n,m}^i\right]^T$, "$\mu_{n,m}^i$" denotes the conditional expected value associated with the channel impulse response and is given by $\mu_{n,m}^i = E\left[h_{n,m}\middle|y_m, \hat{s}^i\right]$, "$\left[x_{n,m}^i\right]_{a,b}$" denotes a conditional expected value associated with a covariance matrix of the channel impulse response and is given by $\left[x_{n,m}^i\right]_{a,b} = E\left[h_{n,m}^a (h_{n,m}^b)^H\middle|y_m, \hat{s}^i\right]$, "C" denotes a space-time block code matrix, "f" denotes an element of a discrete Fourier transform matrix, "M" denotes the number of receiving antennas, "P" denotes the number of sub-carriers, "N" denotes the number of transmitting antennas, "J" denotes the number of paths associated with the channel impulse response, and $C^H C = \beta I$.

3. (Original) The method as set forth in claim 1, wherein the white Gaussian noise is associated with the covariance matrix produced by:

$$\sigma_w^2 I = \rho\sigma_n^2 I$$

where "σ_w^2" denotes a noise variable of the channel from the n[th] transmitting antenna to the m[th] receiving antenna, "σ_n^2" denotes a noise variable of a signal received by the m[th] receiving antenna, "I" denotes an identity matrix, and "ρ" denotes a variance scaling factor.

4. (Original) The method as set forth in claim 3, wherein the variance scaling factor is produced by:

$$\rho = E\left[\frac{\sum_{i=1}^{L}|c_n(l)|^2}{\beta^2}\right]$$

where "$c_n(l)$" denotes an element of a space-time block code matrix C, and $C^H C = \beta I$.

5. (Original) The method as set forth in claim 3, wherein the variance scaling factor is produced by:

STBC	16-QAM	64-QAM
Rate 1(N=2)	0.659	0.700
Rate 3/4(N=3,4)	0.389	0.398
Rate 1/2(N=3,4)	0.139	0.141

6. (Original) The method as set forth in claim 2, wherein the conditional expected value associated with the channel impulse response is produced by:

$$\mu_{n,m}^{i} = K_{n,m} F^{H} z_{n,m}$$

where "$K_{n,m}$" denotes a normalized value of the covariance matrix of the channel impulse response, and "$(\cdot)^{H}$" denotes a Hermitian transpose operation.

7. (Original) The method as set forth in claim 2, wherein the conditional expected value associated with the covariance matrix of the channel impulse response is produced by:

$$x_{n,m}^{i} = \sigma_w^2 K_{n,m} + \mu_{n,m}^{i} (\mu_{n,m}^{i})^{H}$$

where "$K_{n,m}$" denotes a normalized value of the covariance matrix of the channel impulse response, and "$(\cdot)^{H}$" denotes a Hermitian transpose operation.

8. (Original) The method as set forth in claim 6, wherein the normalized value of the covariance matrix of the channel impulse response is produced by:

$$K_{n,m} = (F^{H} F + \sigma_w^2 R_{n,m}^{-1})^{-1}$$

where "R" denotes the covariance matrix of the channel impulse response.

9. (Original) The method as set forth in claim 7, wherein the normalized value of the covariance matrix of the channel impulse response is produced by:

$$K_{n,m} = (F^H F + \sigma_w^2 R_{n,m}^{-1})^{-1}$$

where "R" denotes the covariance matrix of the channel impulse response.

10. (Currently Amended) An apparatus for estimating a sequence of transmitted quadrature amplitude modulation (QAM)-modulated signals and space-time block coded signals using an optimal expectation-maximization (EM)-based iterative estimation algorithm in a multiple-input and multiple-output (MIMO)-orthogonal frequency division multiplexing (OFDM) mobile communication system, comprising:

a pilot detection and initial value estimation unit for producing an initial sequence estimation value according to a predetermined initial value using a pilot sub-carrier contained in each OFDM signal received by a receiving side;

a normalizer for producing a normalized value of ~~a~~ the received signal on a channel-by-channel basis using orthogonality between the OFDM signals received by the receiving side, the normalized value of the received signal being produced by a predetermined equation; and

a sequence estimator for producing at least one subsequent sequence estimation value using the initial sequence estimation value and the normalized value, and designating a converged subsequent sequence estimation value to be a final sequence estimation value if the at least one subsequent sequence estimation value converges to a constant value,

wherein the predetermined equation is given by:

$$z_{n,m} = H_{n,m} + w_{n,m} = Fh_{n,m} + w_{n,m}$$

where "$w_{n,m}$" denotes a white Gaussian noise of a channel from an nth transmitting antenna to an mth receiving antenna, "F" denotes a discrete Fourier transform matrix, and "$h_{n,m}$" denotes an impulse response associated with the channel from the nth transmitting antenna to the mth receiving antenna.

11. (Original) The apparatus as set forth in claim 10, wherein the at least one subsequent sequence estimation value is produced according to a likelihood function produced by:

$$L(s|\hat{s}^i) = \sum_{m=1}^{M}\sum_{p=1}^{P}\left\{\mathrm{Re}\left[(y_m^p)^H C_p \Lambda_m^i f_p\right] - \frac{\beta_p}{2}\sum_{n=1}^{N}\sum_{a=1}^{J}\sum_{b=1}^{J}\left[x_{n,m}^i\right]_{a,b}\left[f_p\right]_a\left[f_p\right]_b^*\right\}$$

where "Λ_m^i" denotes a matrix of a conditional expected value associated with a channel impulse response and is given by $\Lambda_m^i = \left[\mu_{1,m}^i, \mu_{2,m}^i, \cdots, \mu_{n,m}^i\right]^T$, "$\mu_{n,m}^i$" denotes the conditional expected value associated with the channel impulse response and is given by $\mu_{n,m}^i = E\left[h_{n,m}|y_m, \hat{s}^i\right]$, "$\left[x_{n,m}^i\right]_{a,b}$" denotes a conditional expected value associated with a covariance matrix of the channel impulse response and is given by $\left[x_{n,m}^i\right]_{a,b} = E\left[h_{n,m}^a (h_{n,m}^b)^H|y_m, \hat{s}^i\right]$, "C" denotes a space-time block code matrix, "f" denotes an element of a discrete Fourier transform matrix, "M" denotes the number of receiving antennas, "P" denotes the number of sub-carriers, "N" denotes the number of transmitting antennas, "J" denotes the number of paths associated with the channel impulse response, and $C^H C = \beta I$.

12. (Original) The apparatus as set forth in claim 10, wherein the white Gaussian noise is associated with the covariance matrix produced by:

$$\sigma_w^2 I = \rho\sigma_n^2 I$$

where "σ_w^2" denotes a noise variable of a channel from the nth transmitting antenna to the mth receiving antenna, "σ_n^2" denotes a noise variable of a signal received by the mth receiving antenna, "I" denotes an identity matrix, and "ρ" denotes a variance scaling factor.

13. (Original) The apparatus as set forth in claim 12, wherein the variance scaling factor is produced by:

$$\rho = E\left[\frac{\sum_{i=1}^{L} |c_n(l)|^2}{\beta^2}\right]$$

where "$c_n(l)$" denotes an element of a space-time block code matrix C, and $C^H C = \beta I$.

14. (Original) The apparatus as set forth in claim 12, wherein the variance scaling factor is produced by:

STBC	16-QAM	64-QAM
Rate 1(N=2)	0.659	0.700
Rate 3/4(N=3,4)	0.389	0.398
Rate 1/2(N=3,4)	0.139	0.141

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15. (Original) The apparatus as set forth in claim 11, wherein the conditional expected value associated with the channel impulse response is produced by:

$$\mu_{n,m}^{i} = K_{n,m} F^{H} z_{n,m}$$

where "$K_{n,m}$" denotes a normalized value of the covariance matrix of the channel impulse response, and "$(\cdot)^H$" denotes a Hermitian transpose operation.

16. (Original) The apparatus as set forth in claim 11, wherein the conditional expected value associated with the covariance matrix of the channel impulse response is produced by:

$$x_{n,m}^{i} = \sigma_w^2 K_{n,m} + \mu_{n,m}^{i} (\mu_{n,m}^{i})^H$$

where "$K_{n,m}$" denotes a normalized value of the covariance matrix of the channel impulse response, and "$(\cdot)^H$" denotes a Hermitian transpose operation.

17. (Original) The apparatus as set forth in claim 15, wherein the normalized value of the covariance matrix of the channel impulse response is produced by:

$$K_{n,m} = (F^H F + \sigma_w^2 R_{n,m}^{-1})^{-1}$$

where "R" denotes the covariance matrix of the channel impulse response.

18. (Original) The apparatus as set forth in claim 16, wherein the normalized value of the covariance matrix of the channel impulse response is produced by:

$$K_{n,m} = (F^H F + \sigma_w^2 R_{n,m}^{-1})^{-1}$$

where "R" denotes the covariance matrix of the channel impulse response.

19. (Currently Amended) A method for estimating a sequence of transmitted quadrature amplitude modulation (QAM)-modulated signals though an optimal expectation-maximization (EM)-based iterative estimation algorithm using one receiving antenna of a multiple-input and multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) mobile communication system, comprising the steps of:

(a) producing an initial sequence estimation value according to a predetermined initial value using a pilot sub-carrier contained in each OFDM signal received by the receiving antenna;

(b) producing a normalized value of ~~a~~ the received signal using the initial sequence estimation value, the normalized value of the received signal being produced by a predetermined equation;

(c) producing at least one subsequent sequence estimation value using the initial sequence estimation value and the normalized value of the received signal; and

(d) if the at least one subsequent sequence estimation value converges to a constant value, designating the converged subsequent sequence estimation value to be a final sequence estimation value,

wherein the predetermined equation is given by:

$$y' = (s^i)^{-1} y = Fh + n'$$

where "F" denotes a discrete Fourier transform matrix, "h" denotes a channel impulse response, and "n′" denotes a channel white Gaussian noise.

20. (Original) The method as set forth in claim 19, wherein the at least one subsequent sequence estimation value produced step (c) is produced according to a likelihood function produced by :

$$Q(s|s^i) = \sum_{k=-N_a}^{N_a} \left\{ \mathrm{Re}\left[y^*(k) s(k) \sum_{l=1}^{L} [F]_{k,l} m_1^i(l) \right] - \frac{1}{2} |s_k|^2 \sum_{l=1}^{L} \sum_{m=1}^{L} [F]_{k,l} [F]^*_{k,m} m_2^i(l,m) \right\}$$

where "F" denotes a discrete Fourier transform matrix, "m_1^i" denotes a conditional expected value associated with the channel impulse response, "m_2^i" denotes a conditional expected value associated with a covariance matrix of the channel impulse response, and "L" denotes a number of channels.

21. (Original) The method as set forth in claim 19, wherein the white Gaussian noise is produced by:

$$\sigma_{n'}^2 = \frac{1}{M} \sum_{m=1}^{M} \frac{\sigma_n^2}{|s_m|^2} = \beta \sigma_n^2$$

where "s_m" denotes an mth symbol based on M-ary QAM, "β" denotes a variance scaling factor, and "σ_n^2" denotes a noise variable.

22. (Original) The method as set forth in claim 21, wherein the variance scaling factor is β=1.998 for 16-QAM.

23. (Original) The method as set forth in claim 21, wherein the variance scaling factor is β=2.6854 for 64-QAM.

24. (Original) The method as set forth in claim 20, wherein the conditional expected value associated with the channel impulse response is produced by:

$$m_1^i = \left[m_1^i(1), m_1^i(2), \cdots, m_1^i(L)\right]^T = E[h|y, s^i] = (R')^i F^H y$$

where "$(\cdot)^H$" denotes a Hermitian transpose operation, and "R'" denotes a normalized value of a covariance matrix of the channel impulse response.

25. (Original) The method as set forth in claim 20, wherein a normalized value of the covariance matrix of the channel impulse response is produced by:

$$m_2^i = \begin{bmatrix} m_2^i(1,1) & m_2^i(1,2) & \cdots & m_2^i(1,L) \\ m_2^i(2,1) & m_2^i(2,2) & \cdots & m_2^i(2,L) \\ & \cdots & & \\ m_2^i(L,1) & m_2^i(L,2) & \cdots & m_2^i(L,L) \end{bmatrix} = E[hh^H|y, s^i] = \sigma_n^2 (R')^i + m_1^i (m_1^i)^H$$

where "$(\cdot)^H$" denotes a Hermitian transpose operation, and "R'" denotes a normalized value of the covariance matrix of the channel impulse response.

26. (Original) The method as set forth in claim 24, wherein the normalized value of the covariance matrix of the channel impulse response is produced by:

$$(R')^i = \left[\sigma_{n'}^2 R_h^{-1} + F^H F\right]^{-1}$$

where "R_h" denotes the covariance matrix of the channel impulse response.

27. (Original) The method as set forth in claim 25, wherein the normalized value of the covariance matrix of the channel impulse response is produced by:

$$(R')^i = \left[\sigma_{n'}^2 R_h^{-1} + F^H F\right]^{-1}$$

where "R_h" denotes the covariance matrix of the channel impulse response.

28. (Currently Amended) An apparatus for estimating a sequence of transmitted quadrature amplitude modulation (QAM)-modulated signals though an optimal expectation-maximization (EM)-based iterative estimation algorithm using one receiving antenna of a multiple-input and multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) mobile communication system, comprising:

a pilot detection and initial value estimation unit for producing an initial sequence estimation value according to a predetermined initial value using a pilot sub-carrier contained in each OFDM signal received by a receiving side;

a normalizer for producing a normalized value of ~~a~~ the received signal using the initial sequence estimation value, the normalized value of the received signal being produced by a predetermined equation; and

a sequence estimator for producing at least one subsequent sequence estimation value using the initial sequence estimation value and the normalized value, and designating a converged subsequent sequence estimation value to be a final sequence estimation value if the at least one subsequent sequence estimation value converges to a constant value,

wherein the predetermined equation is:

$$y' = (s^i)^{-1} y = Fh + n'$$

where "F" denotes a discrete Fourier transform matrix, "h" denotes a channel impulse response, and "n′" denotes a channel white Gaussian noise.

29. (Original) The apparatus as set forth in claim 28, wherein the at least one subsequent sequence estimation value is produced according to a likelihood function produced by:

$$Q(s|s^i) = \sum_{k=-N_a}^{N_a} \left\{ \mathrm{Re}\left[y^*(k)\, s(k) \sum_{l=1}^{L} [F]_{k,l}\, m_1^i(l) \right] - \frac{1}{2}|s_k|^2 \sum_{l=1}^{L} \sum_{m=1}^{L} [F]_{k,l} [F]^*_{k,m}\, m_2^i(l,m) \right\}$$

where "F" denotes the discrete Fourier transform matrix, "m_1^i" denotes a conditional

expected value associated with the channel impulse response, "m_2^i" denotes a conditional expected value associated with a covariance matrix of the channel impulse response, and "L" denotes the number of channels.

30. (Original) The apparatus as set forth in claim 28, wherein the white Gaussian noise is produced by:

$$\sigma_{n'}^2 = \frac{1}{M}\sum_{m=1}^{M}\frac{\sigma_n^2}{|s_m|^2} = \beta\sigma_n^2$$

where "s_m" denotes an m[th] symbol based on M-ary QAM, "β" denotes a variance scaling factor, and "σ_n^2" denotes a noise variable.

31. (Original) The apparatus as set forth in claim 30, wherein the variance scaling factor is β=1.998 for 16-QAM.

32. (Original) The apparatus as set forth in claim 30, wherein the variance scaling factor is β=2.6854 for 64-QAM.

33. (Original) The apparatus as set forth in claim 29, wherein the conditional expected value associated with the channel impulse response is produced by:

$$m_1^i = [m_1^i(1), m_1^i(2), \cdots, m_1^i(L)]^T = E[h|y, s^i] = (R')^i F^H y$$

where "$(\cdot)^H$" denotes a Hermitian transpose operation, and "R'" denotes a normalized value of the covariance matrix of the channel impulse response.

34. (Original) The apparatus as set forth in claim 29, wherein a normalized value of the covariance matrix of the channel impulse response is produced by an equation of:

$$m_2^i = \begin{bmatrix} m_2^i(1,1) & m_2^i(1,2) & \cdots & m_2^i(1,L) \\ m_2^i(2,1) & m_2^i(2,2) & \cdots & m_2^i(2,L) \\ & \cdots & & \\ m_2^i(L,1) & m_2^i(L,2) & \cdots & m_2^i(L,L) \end{bmatrix} = E[hh^H | y, s^i] = \sigma_n^2 (R')^i + m_1^i (m_1^i)^H$$

where "$(\cdot)^H$" denotes a Hermitian transpose operation, and "R'" denotes a normalized value of the covariance matrix of the channel impulse response.

35. (Original) The apparatus as set forth in claim 33, wherein a normalized value of the covariance matrix of the channel impulse response is produced by an equation of:

$$(R')^i = \left[\sigma_{n'}^2 R_h^{-1} + F^H F\right]^{-1}$$

where "R_h" denotes the covariance matrix of the channel impulse response.

36. (Original) The apparatus as set forth in claim 34, wherein the normalized value of the covariance matrix of the channel impulse response is produced by:

$$(R')^i = \left[\sigma_{n'}^2 R_h^{-1} + F^H F\right]^{-1}$$

where "R_h" denotes the covariance matrix of the channel impulse response.